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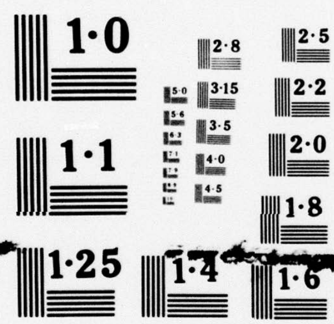
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MATERIALS NOTE 117

THE INFLUENCE OF CATALYST CONCENTRATION AND TEMPERATURE ON THE CURING TIME OF MAGNETIC RUBBER

L. WILSON

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by

10 L. WILSON

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SUMMARY

Variations in ambient temperatures affect the curing time of magnetic rubber replicas taken in the field for the non-destructive inspection of certain aircraft components. This can result in poor quality replicas which are unsuitable for inspection purposes.

This report describes how the problem may be overcome by varying the quantities of catalyst added to the base material.

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16. ABSTRACT

Variations in ambient temperatures affect the curing time of magnetic rubber replicas taken in the field during the non-destructive testing of certain aircraft components. This can result in poor quality replicas which are unsuitable for inspection purposes. This report describes how the problem may be overcome by varying the quantities of catalyst added to the base material.

CONTENTS

1. INTRODUCTION

The inspection of certain steel aircraft components for cracks and/or other flaws has been carried out at these Laboratories and at RAAF bases using a magnetic rubber inspection technique for a number of years. The technique involves the production and inspection of a replica of the area under investigation. The replica is made from a room-temperature curing elastomeric compound (MR 502) in which a black magnetic powder is dispersed. Under the influence of a magnetic flux, the black particles migrate through the suspension, while it is still fluid, and segregate at the location of surface defects. Such defects can therefore be detected and located by optical examination of the cured elastomer after it is removed from the component. This method of crack detection is highly satisfactory in the laboratory, where conditions are easily controlled, but difficulties have been encountered in the field where changes in ambient temperature cause changes in cure times.

Since the cure time depends on the concentration of catalyst as well as the temperature of curing, an investigation was undertaken to determine the concentrations of catalyst which would produce the optimum time of curing at various ambient temperatures.

2. EXPERIMENTAL

2.1 General

A bolt hole in an aircraft component, known to have a crack (arrowed in Figure I) which was easily detectable under ideal conditions, was used as a reference throughout the investigation. Figure I shows a replica of this hole made using the recommended formula of 10 grams of magnetic rubber base material MR 502, 2 drops of cure stabiliser, and 7 drops of dibutyl tin laurate catalyst at an ambient temperature of 20° Celsius. Replicas made under these conditions cured sufficiently after approximately 1 hour to allow their removal and inspection.

2.2 Standardisation of quantity of catalyst

The catalyst and the cure stabiliser are supplied in dropping bottles and the manufacturer recommends that they be used by counting a specified number of drops. However, drops can vary in size and it was decided to use measured volumes rather than drops. Tests showed that the average volume of the specified 7 drops of catalyst was 0·15 millilitres and that of the 2 drops of stabiliser was 0·04 millilitres.

2.3 Effect of temperature on crack detection and cure time

Using a formula of $10 \pm 0 \cdot 1$ grams of magnetic base material, 0·04 millilitres of stabiliser and 0·15 millilitres of catalyst mixed together for 30 seconds, replicas of the reference hole were made at temperatures of 14, 20, 22, 25, 28, 34, and 40° Celsius. These replicas are shown in Figure 2. For curing temperatures above 25°C, the crack is not nearly as well-defined as at 25°C and below, presumably because the curing times at the higher temperatures were too short to allow optimum migration of the magnetic powder particles. Furthermore, at 14°C, the mixture took approximately 90 minutes to cure sufficiently for the replica to be removed from the hole for inspection.

2.4 Effect of catalyst concentration on crack detection and cure time at various temperatures

A number of mixtures made under ideal laboratory conditions (at 20°C using 10 grams of magnetic rubber base material, 0·04 millilitres of cure stabiliser and 0·15 millilitres of catalyst) gave an average cure time of 63 ± 2 minutes and good definition of the cracked surface

of the reference bolt hole. The cure times were measured by dropping a wooden stick (15 centimetres long, 2 millimetres diameter and weighing 0·45 grams) onto the mixture from a height of 5 centimetres. When the end of the stick no longer made any impression on the surface of the mixture, curing was considered to be satisfactory. The cure times of mixtures containing various concentrations of catalyst were determined at various temperatures from 3° to 53°C (Fig. 3). The concentrations of catalyst requred to give cure times of 63 minutes at the various temperatures (determined from Fig. 3) are shown in Figure 4.

3. DISCUSSION

The investigation showed that the recommended formula for producing magnetic rubber replicas of defects in steel aircraft components was unsatisfactory at temperatures above and below 25°C; because the curing time at temperatures above 25°C was too short to allow the magnetic particles to migrate through the matrix to the defect (Fig. 2) and, at temperatures below 20°C, because the matrix took too long to cure.

Tests showed (Fig. 3) that the cure time could be altered by varying the concentration of catalyst. Small differences in catalyst concentration markedly affected the cure time, particularly at temperatures above 20°C and cure times of the order of 1 hour.

At the lower temperatures, the quantity of catalyst necessary to complete the curing process in the desired time increases quite sharply from 0·15 millilitres ($\approx$ 7 drops) at 20°C to 1·50 millilitres ($\approx$ 75 drops) at 3°C (Fig.3). For these reasons, the quantity of catalyst required at a particular temperature, as determined from Figure 4, should be measured accurately, e.g. from a 5 millilitre burette, rather than by counting the drops from a dropping bottle.

4. CONCLUSIONS

(i) Variations in temperature affect the cure time of magnetic rubber formulations.
(ii) Variations in temperature can be compensated for by varying the quantities of catalyst used.
(iii) The quantities of catalyst used must be measured accurately.

MAG. x 15

FIG. 1. MAGNETIC RUBBER REPLICA,OF REFERENCE HOLE,MADE UNDER OPTIMUM CONDITIONS

MAG. x 5

FIG. 2. MAGNETIC RUBBER REPLICAS OF THE REFERENCE HOLE MADE AT VARIOUS TEMPERATURES
Top row – left to right 28°C, 34°C, 40°C
Bottom row – left to right 14°C, 20°C, 22°C, 25°C

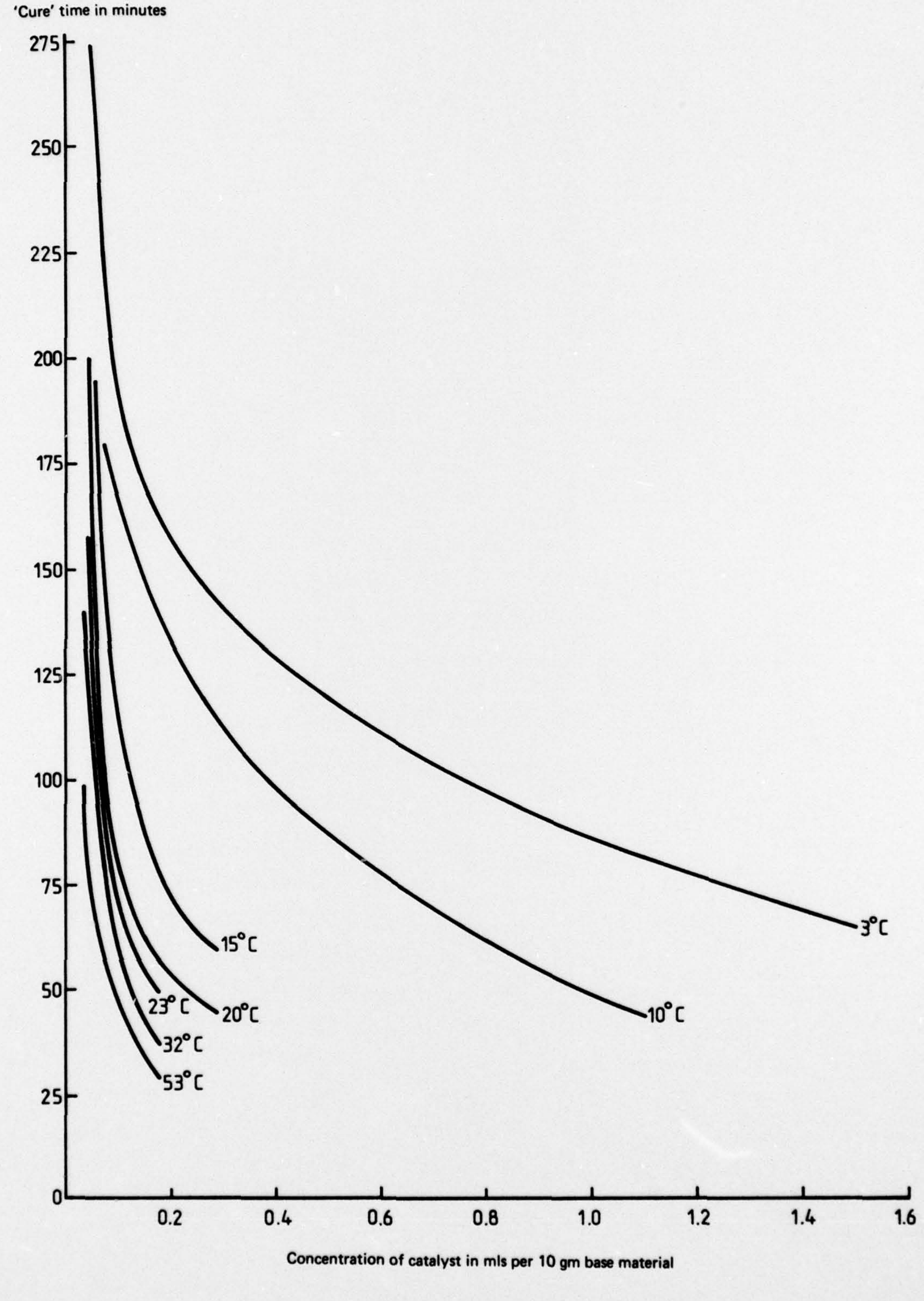

FIG. 3. VARIATION OF 'CURE' TIME WITH CATALYST CONCENTRATION AT VARIOUS TEMPERATURES

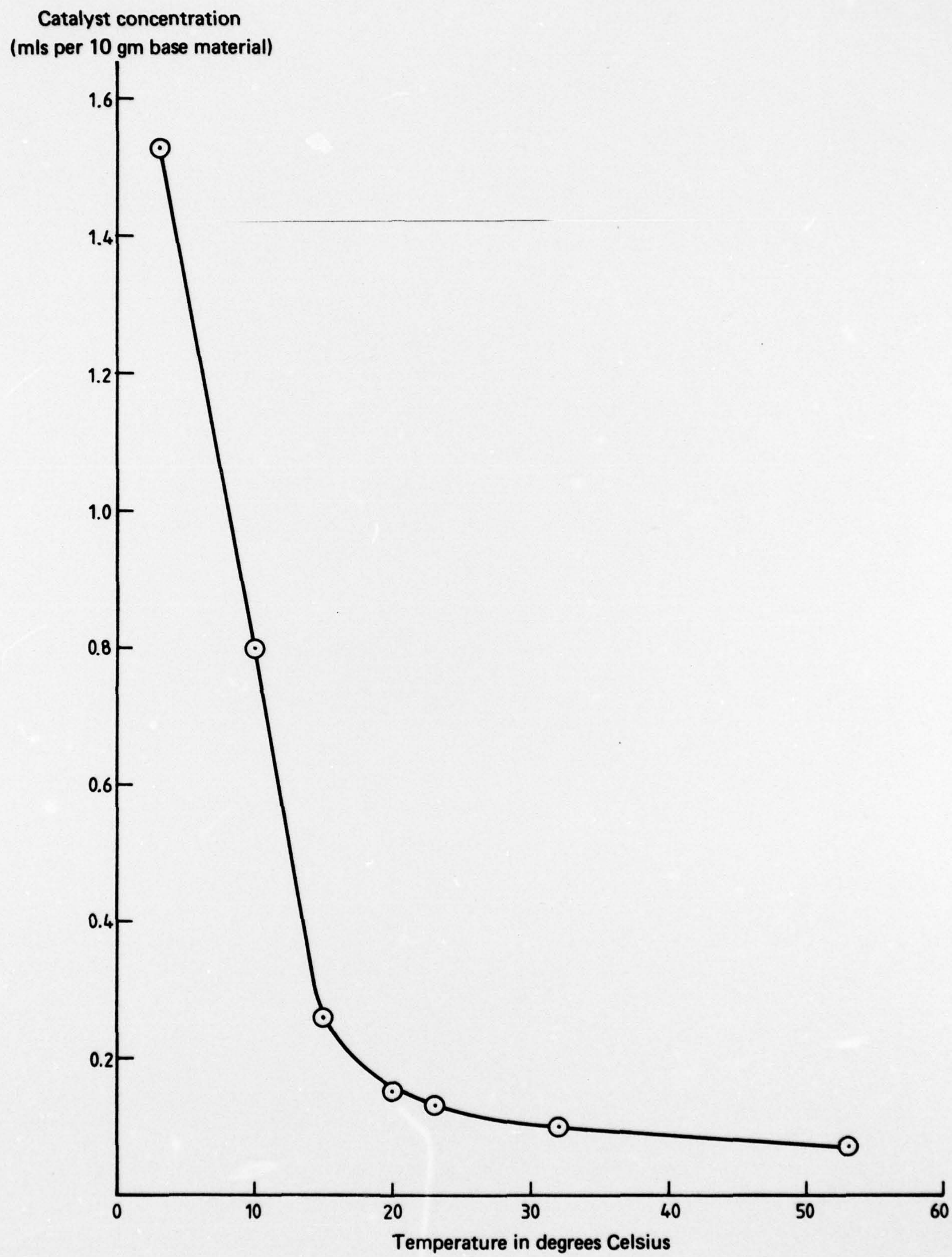

FIG. 4. VARIATION OF CATALYST CONCENTRATION WITH TEMPERATURE FOR 63 MINUTE 'CURE' TIME.

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